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Yamanaka

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(54) **BICYCLE CRANK ARM PARTS/ASSEMBLY AND ASSEMBLY TOOLS**

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(73) Assignee: **Shimano, Inc.**, Osaka (JP)

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This patent is subject to a terminal disclaimer.

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(51) **Int. Cl.**[7] **G05G 1/14**

(52) **U.S. Cl.** **74/594.1**; 74/594.2

(58) **Field of Search** 74/594.1–594.3; 384/545

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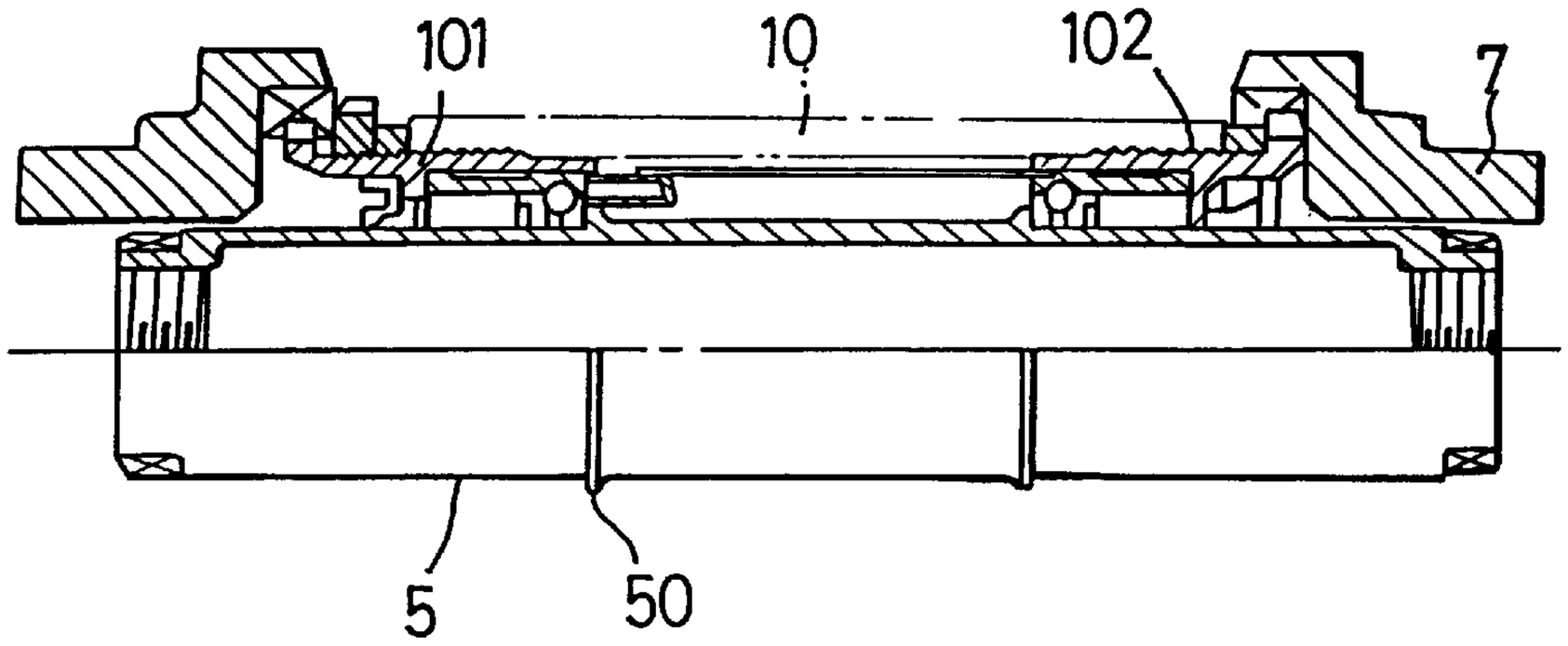
(57) **ABSTRACT**

A crank axle includes an axle body having first and second ends, a first rotary linkage member disposed at the first end of the axle body for nonrotatably fitting a first crank arm thereto, and a first centering structure disposed at the first end of the axle body in close proximity to the first rotary linkage member. The rotary linkage member may be formed as a plurality of splines, and the same structure may be formed at the second end.

50 Claims, 10 Drawing Sheets



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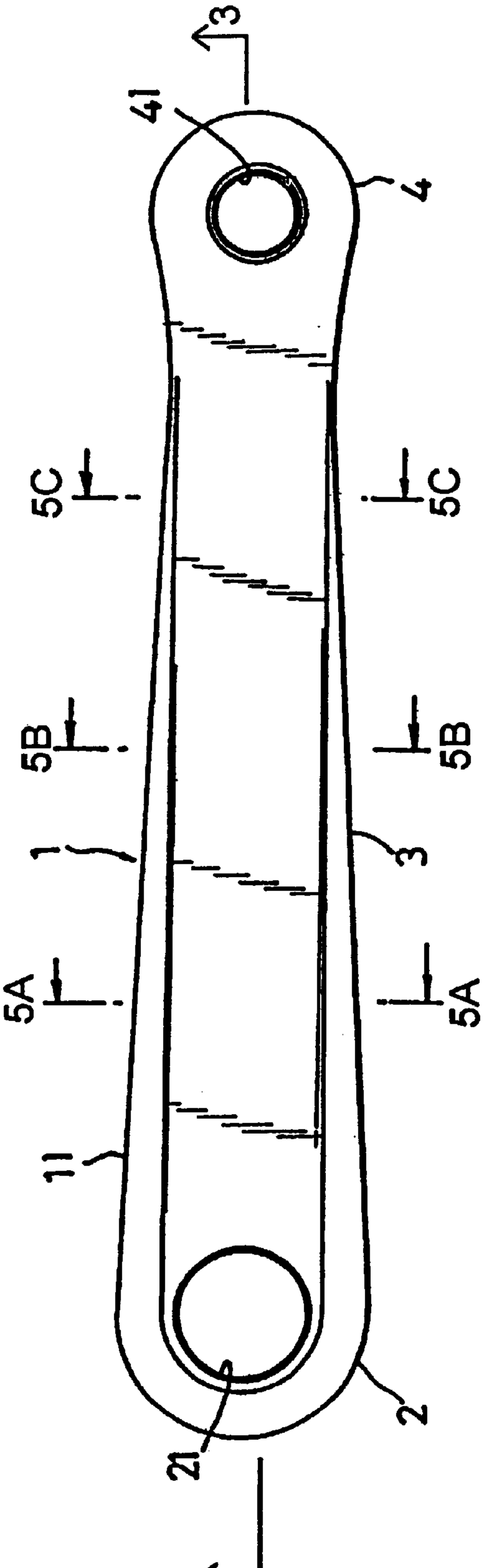


FIG.1

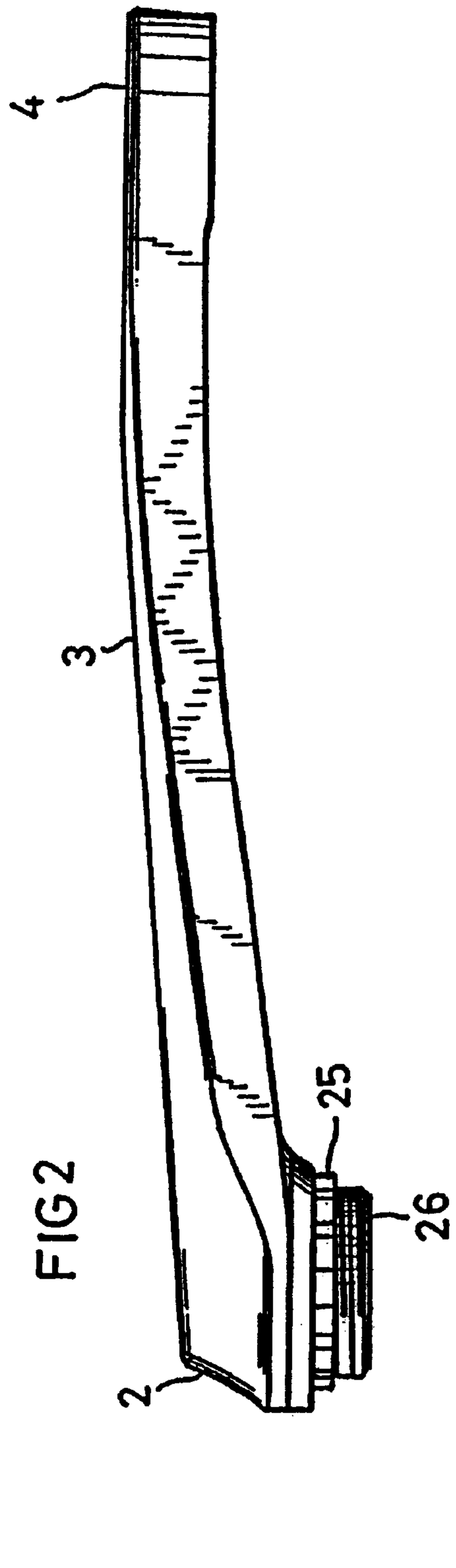


FIG2

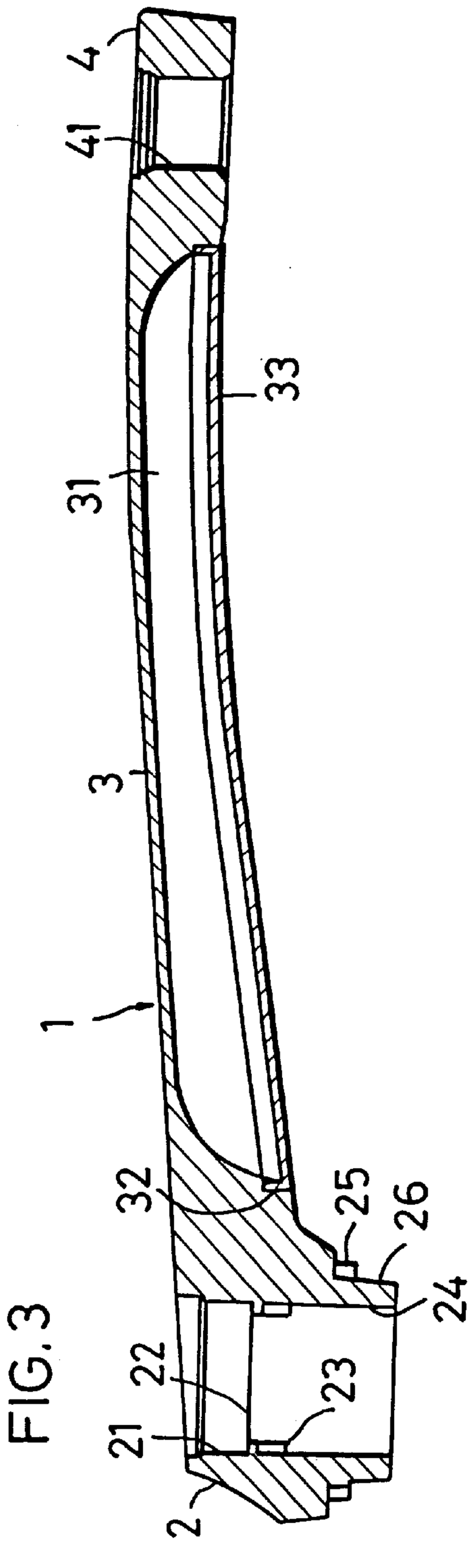


FIG. 3

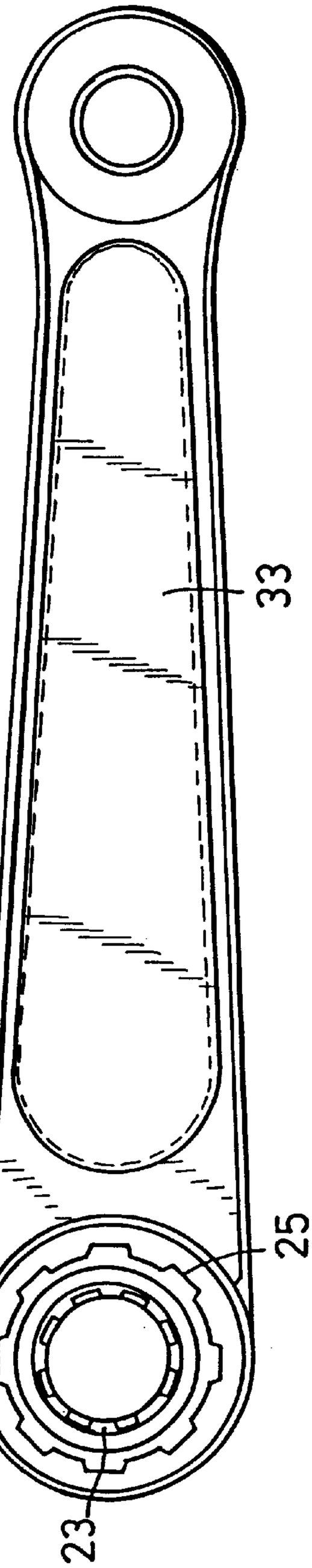


FIG. 4

FIG. 5(A)

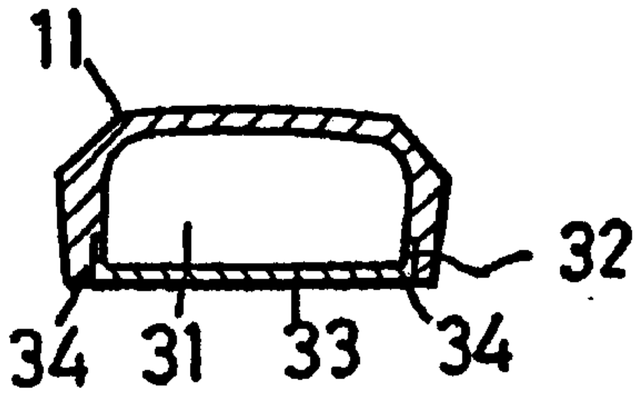


FIG. 5(B)

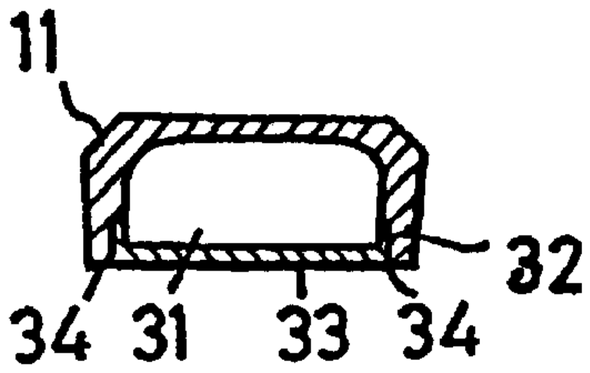


FIG. 5(C)

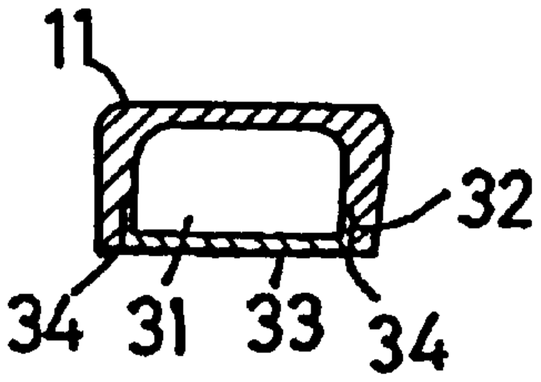


FIG.6

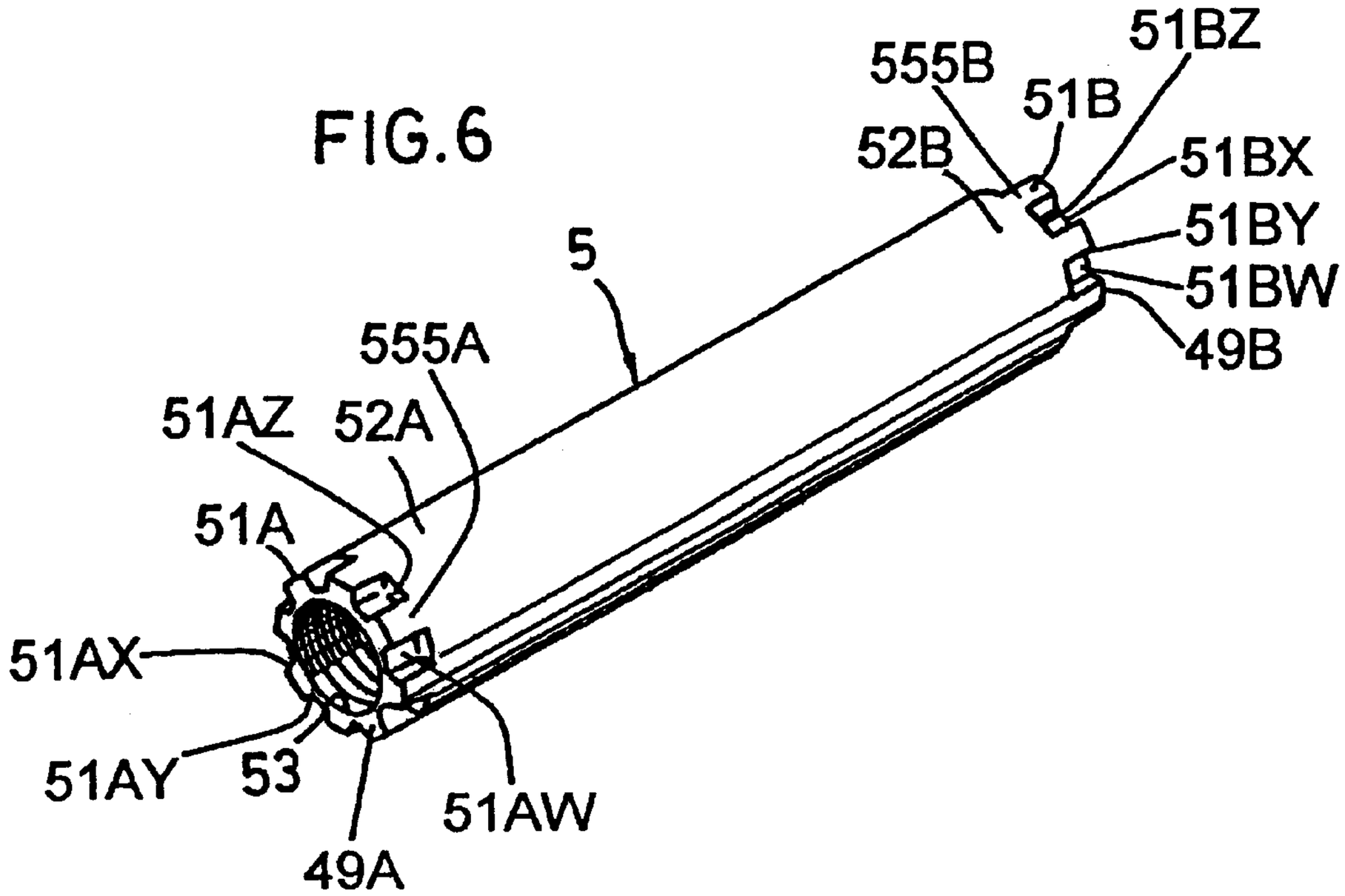


FIG. 7

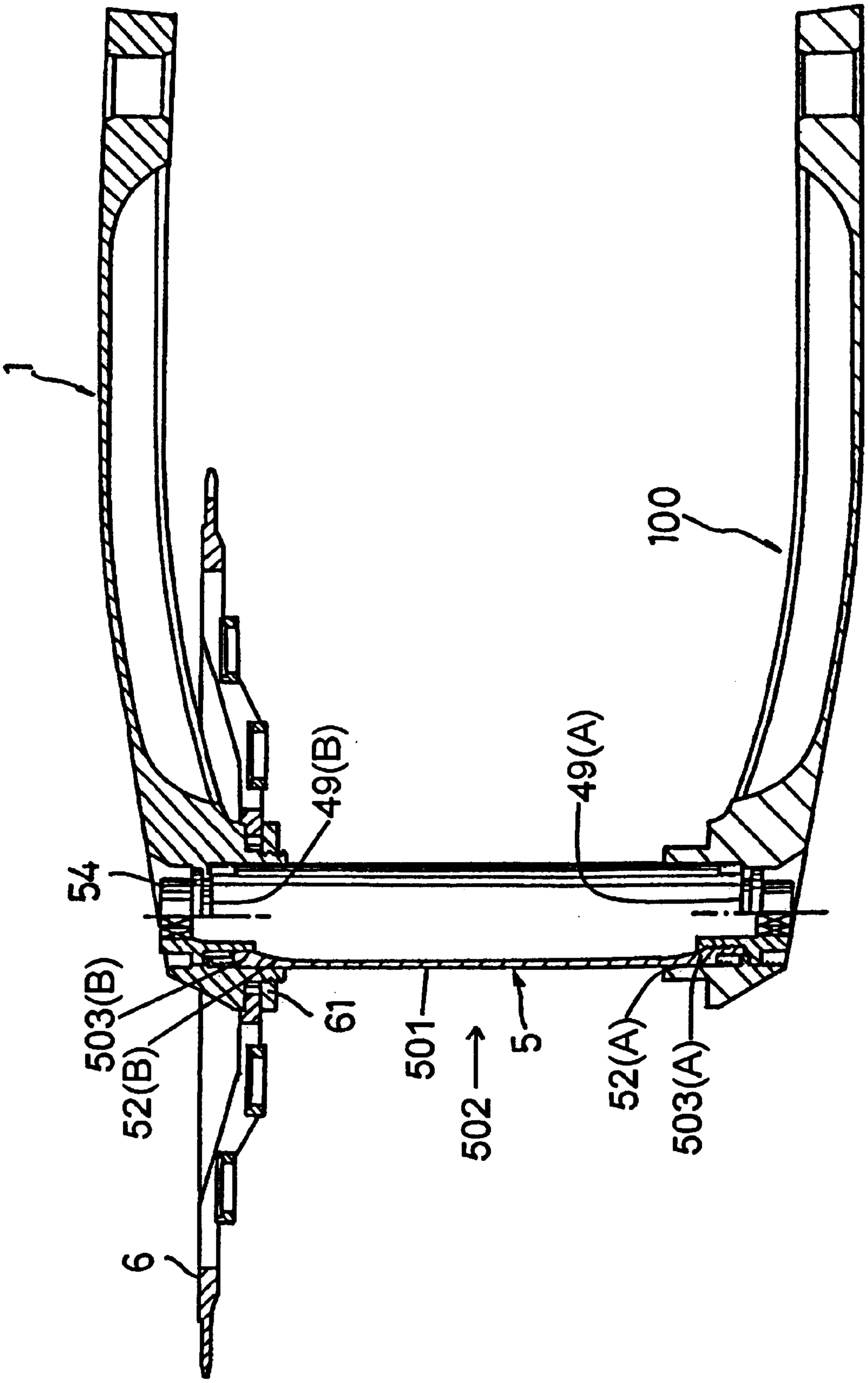


FIG. 8

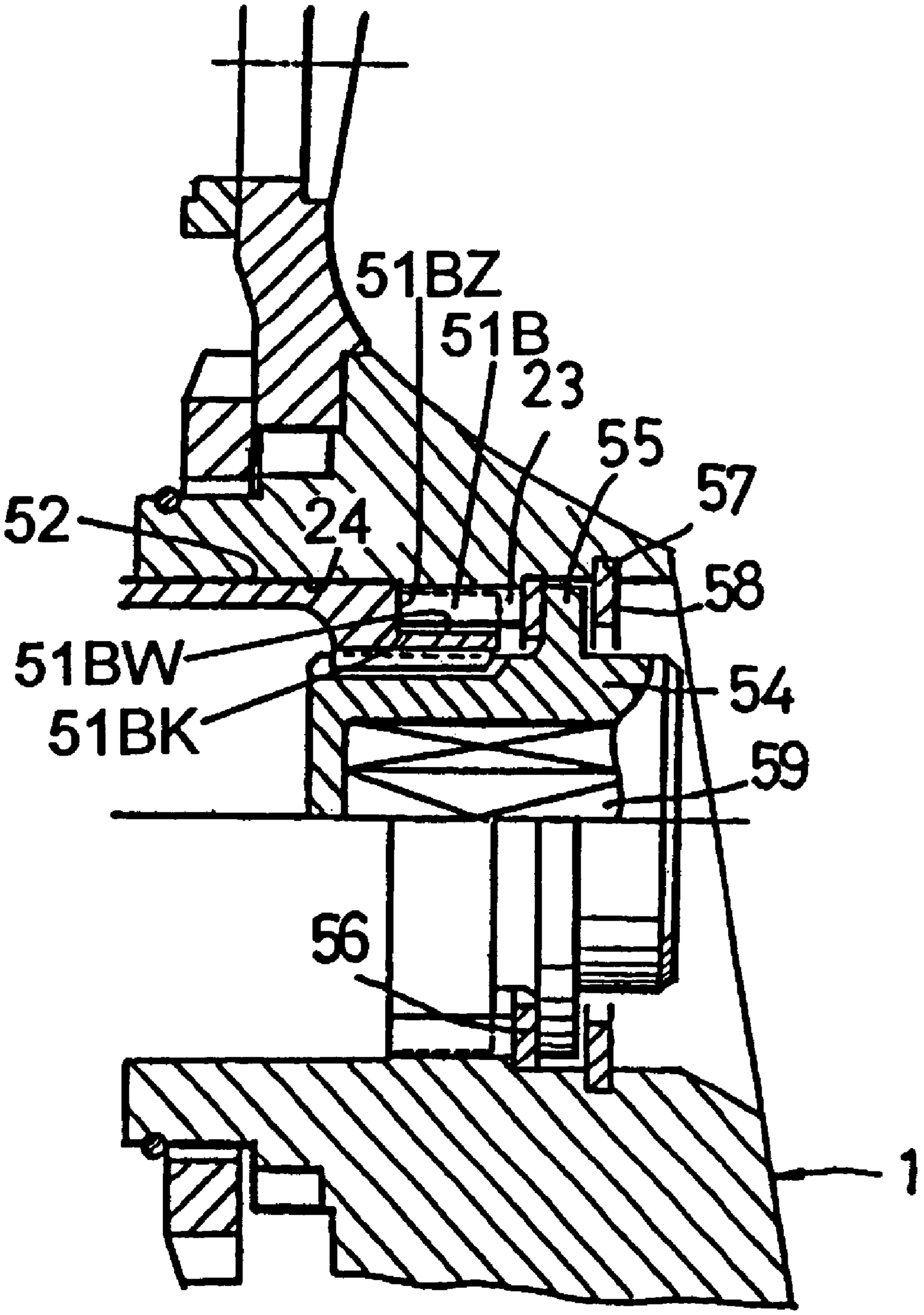


FIG.9

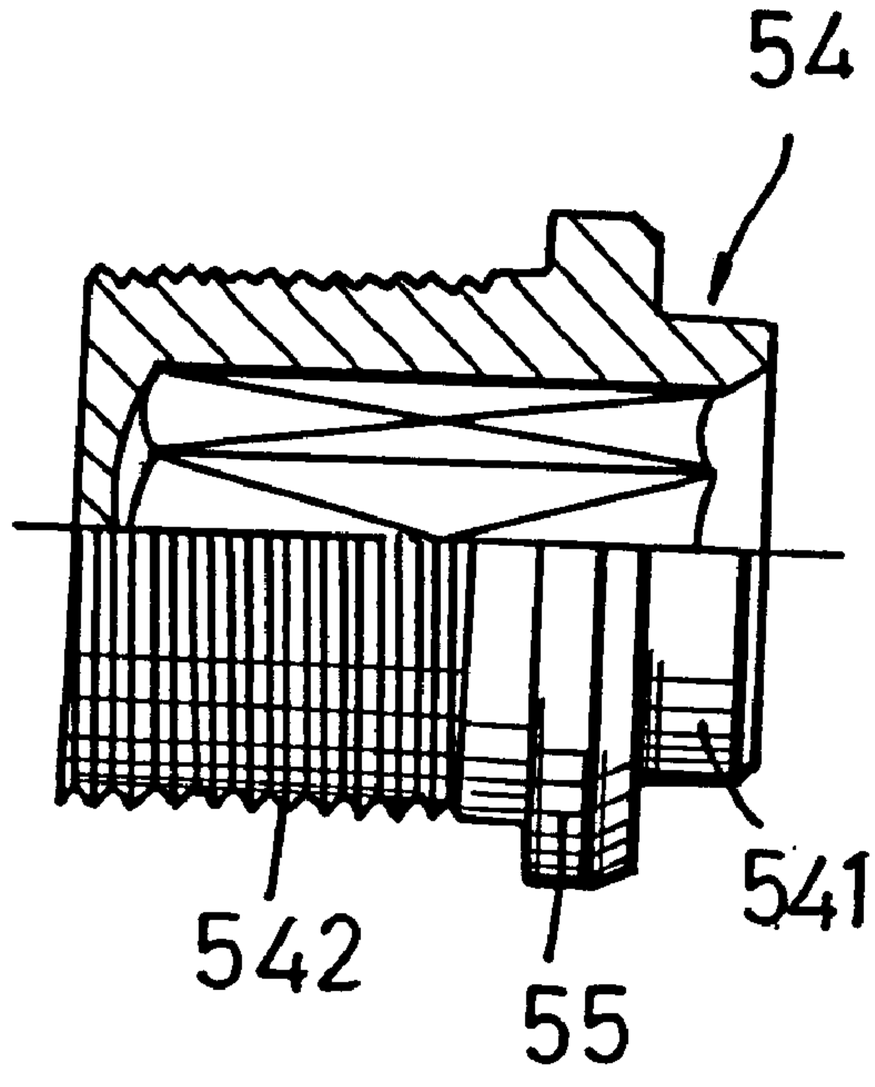


FIG.10

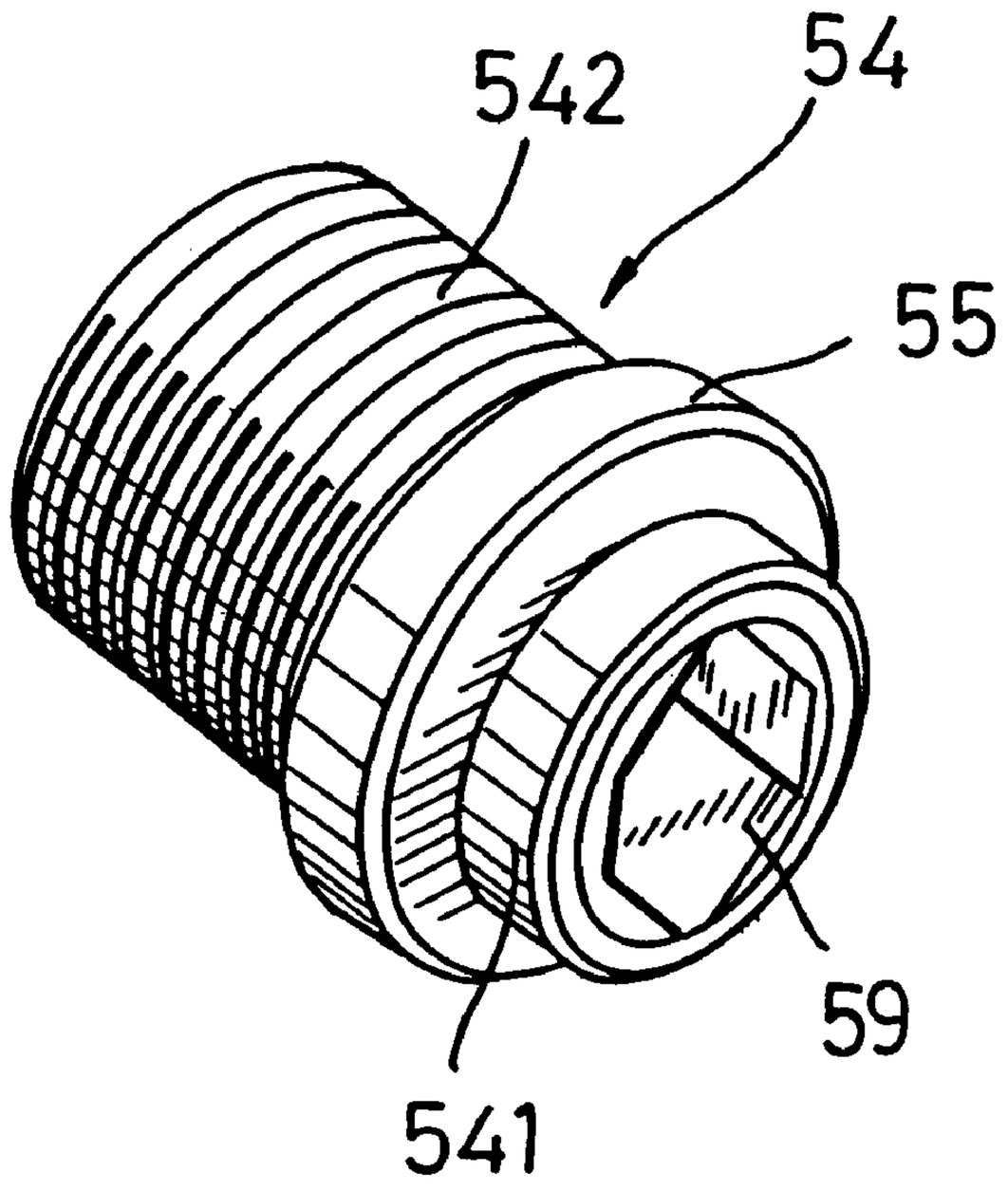


FIG.11

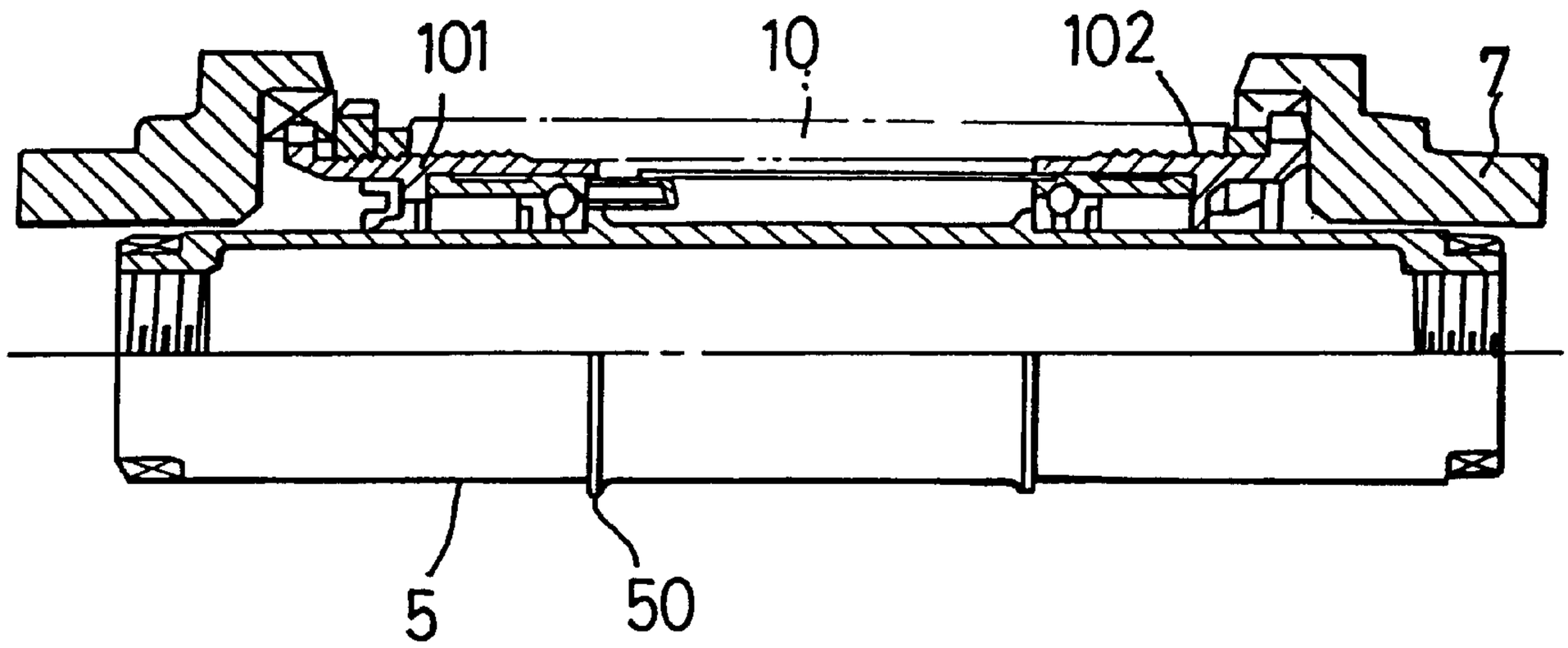


FIG.12

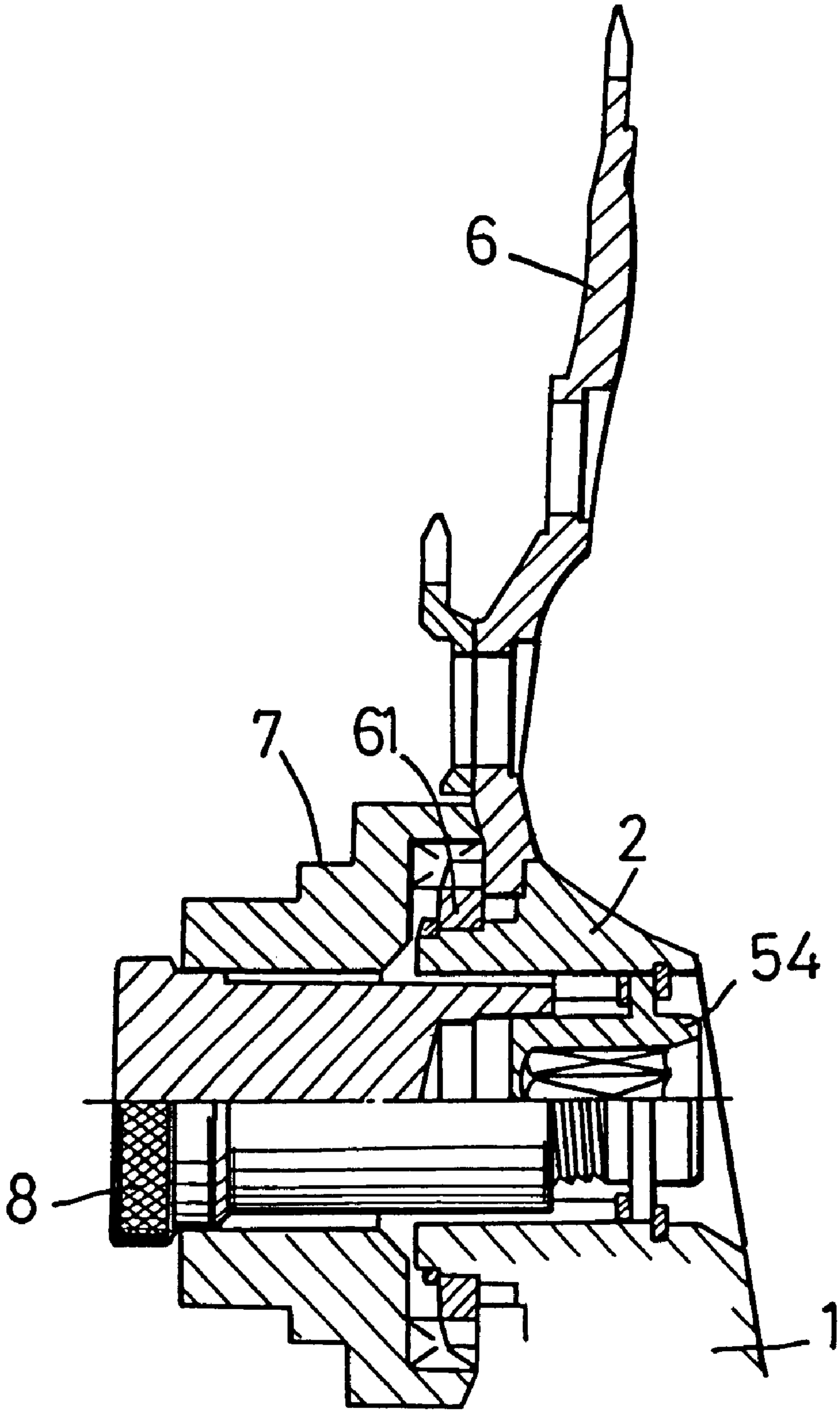


FIG.13

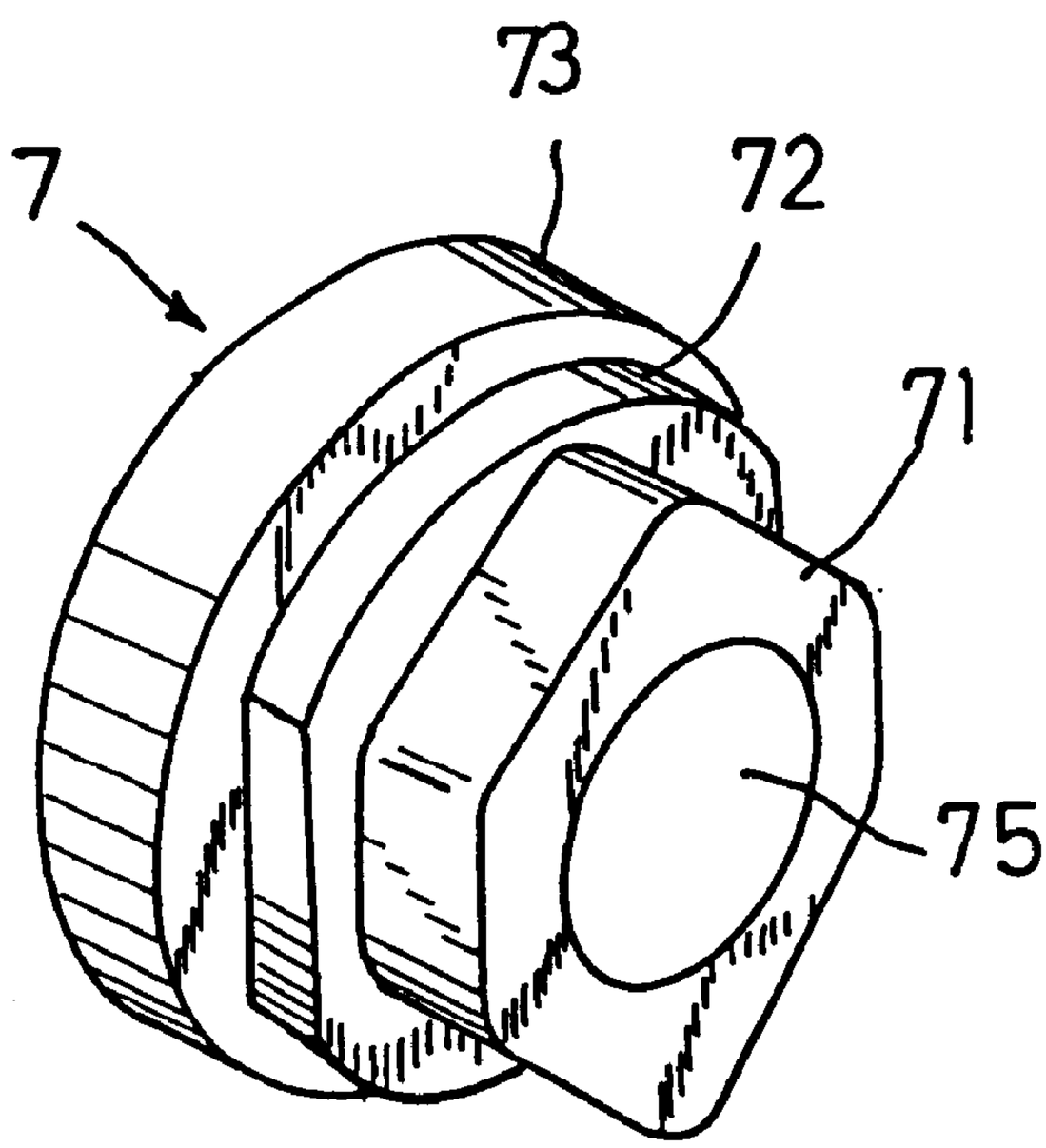


FIG.14

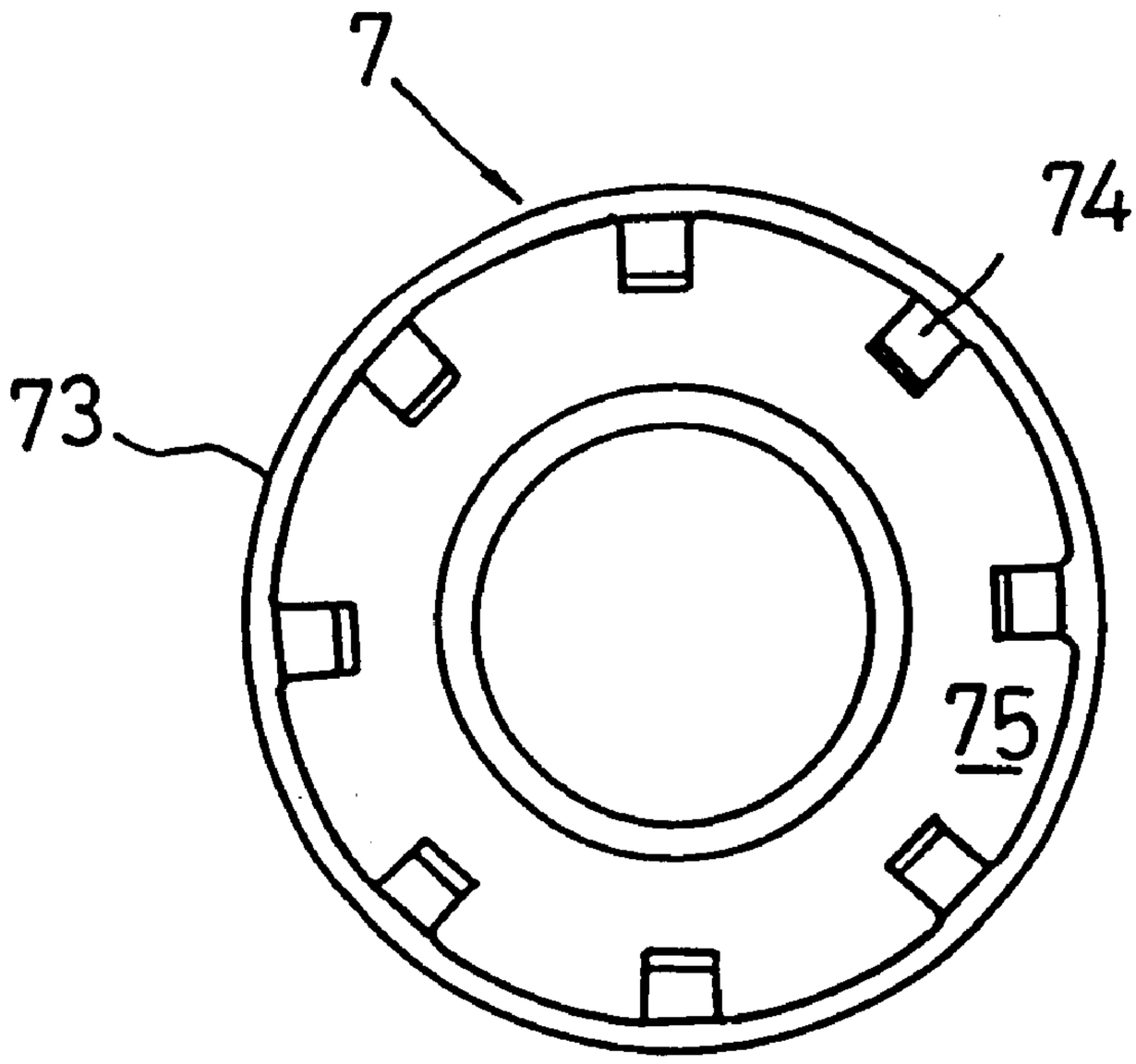
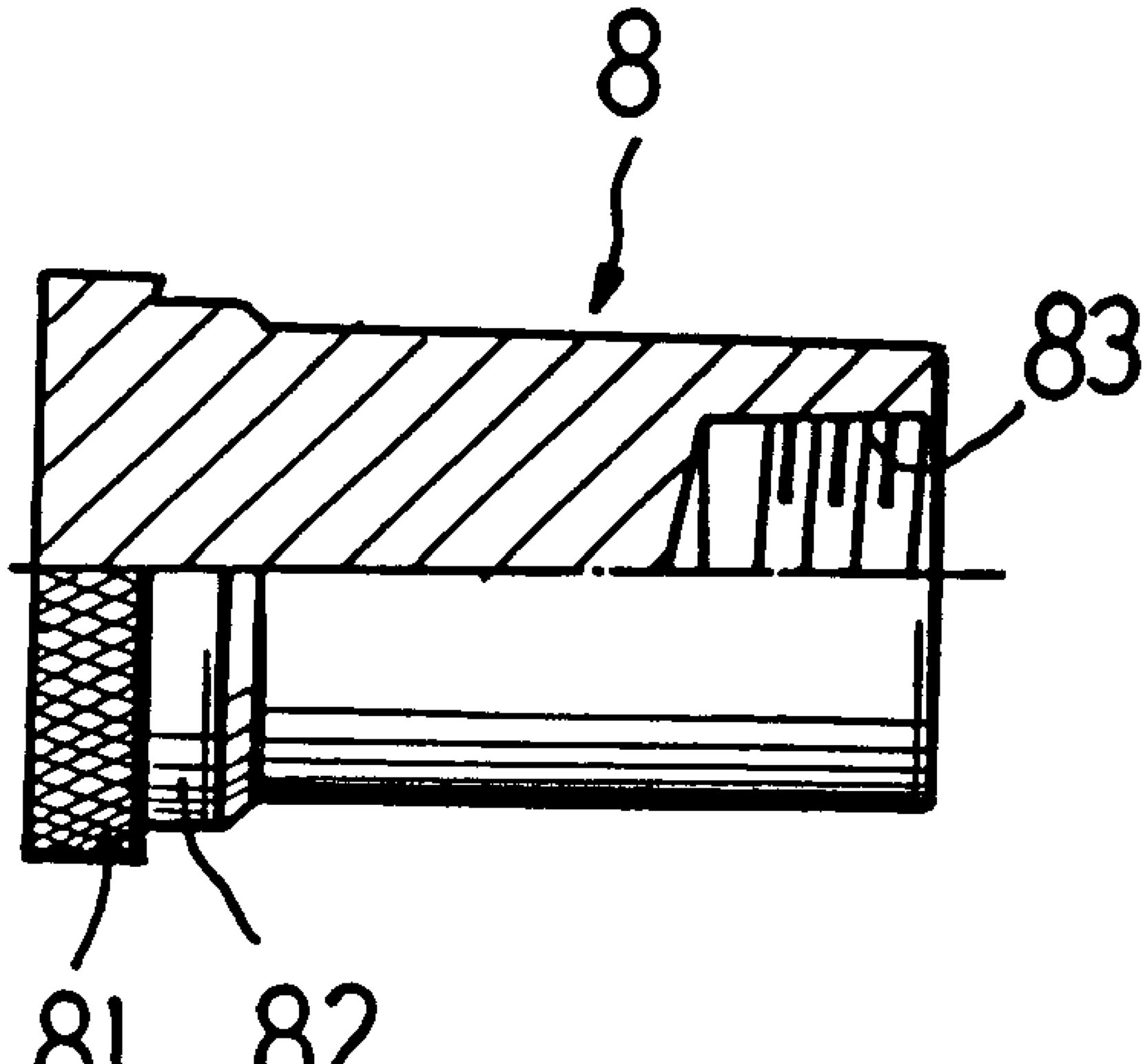


FIG.15



BICYCLE CRANK ARM PARTS/ASSEMBLY AND ASSEMBLY TOOLS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a division of application Ser. No. 08/890,744, filed Jul. 11, 1997, now U.S. Pat. No. 6,276,885 which is a division of application Ser. No. 08/687,203, Jul. 25, 1996 now U.S. Pat. No. 5,845,543.

BACKGROUND OF THE INVENTION

The present invention is directed to a bicycle crank axle, a crank arm, and a crank set that offer high mounting precision and fastening strength, and that contribute to lighter weight. It also relates to a bolt and assembly tools used for assembling these components.

In conventional mounting mechanisms for the crank arms and crank axle in a bicycle, both ends of the crank axle are shaped into essentially square columns, a square hole is made in each crank arm, and the two are fitted together to fasten the crank arm onto the axle. The precision of centering afforded by the conventional mechanism for fitting together the crank arms and the crank axle is inadequate, and the strength of the linkage in the direction of rotation is inadequate as well. The problem of inadequate linkage strength is particularly notable where an aluminum alloy hollow pipe structure has been adopted for the crank axle, or where an aluminum alloy hollow structure has been adopted for the crank arms in order to reduce weight.

SUMMARY OF THE INVENTION

The present invention is directed to a bicycle crank axle, a crank arm, and a crank set that offer high mounting precision and fastening strength, but also contribute to lighter weight. Novel bolt and assembly tools used are for installing and removing these components so that assembly and disassembly may be accomplished very easily.

In one embodiment of the present invention, a crank axle includes an axle body having first and second ends, a first rotary linkage member disposed at the first end of the axle body for nonrotatably fitting a first crank arm thereto, and a first centering structure disposed at the first end of the axle body in close proximity to the first rotary linkage member. If desired, the rotary linkage member may be formed as a plurality of splines, and the same structure may be formed at the second end. A crank arm for fitting to the crank axle includes a crank axle mounting section having a centering structure for centering the crank axle mounting section to an end of a crank axle, and a rotary linkage member for nonrotatably fitting the crank axle mounting section to the end of the crank axle. If desired, the rotary linkage member for the crank arm may comprise splines that mesh with splines on the end of the crank axle. Such a structure provides secure linking of the crank arm to the crank axle without adding excessive weight.

To facilitate removal of the crank arm, a special bolt is used to fix the crank arm to the crank axle. The bolt includes a head, a threaded section having a diameter greater than or equal to the head, and a flange disposed between the head and the threaded section. The flange preferably has a diameter greater than the diameter of the threaded section, and the head defines a multiple-sided tool-engaging hole which extends axially into the threaded section to maximize the tool engaging surface. The crank axle mounting section of the crank arm preferably includes a stop ring or similar

structure located so that the flange of the bolt is disposed between the stop ring and the first end of the axle body. As a result, the bolt flange presses the crank arm apart from the crank axle when the bolt is loosened.

Special tools may be provided to allow easy installation and removal of the components. For example, a tool that can be used for both fixing the axle to the bicycle and fixing a chainwheel to the crank arm includes a tool-mount member shaped to be held and turned by a tool, wherein the tool-mount member defines an opening for receiving a portion of the axle body therethrough. An operating member having a plurality of splines formed on an inside surface thereof is coupled to the tool-mount member. The splines may engage corresponding splines on a mounting adapter for the crank axle or corresponding splines on a nut used to fix a chainwheel to the crank arm. In the latter case, an auxiliary tool may be provided to ensure stable operation of the tool. The auxiliary tool may include a grip section disposed in close proximity to a first end thereof, wherein the grip section has a diameter greater than or equal to a diameter of an end of the crank axle. A support section may be disposed adjacent to the grip section and sized to fit within the opening in the tool-mount member. A second end of the auxiliary tool has a threaded inner peripheral surface which can engage with the bolt used to mount the crank arm to the axle. In this case the bolt serves to temporarily fix the main and auxiliary tool to the crank arm so that the main tool can reliably tighten the chainring fixing nut.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a front view of a particular embodiment of a crank arm according to the present invention;

FIG. **2** is a side view of the crank arm shown in FIG. **1**;

FIG. **3** is a longitudinal cross sectional view of the crank arm shown in FIG. **1**;

FIG. **4** is a rear view of the crank arm shown in FIG. **1**;

FIGS. **5**A–**5**C are cross sectional views taken along lines **5**A—**5**A, **5**B—**5**B and **5**C—**5**C, respectively, in FIG. **1**;

FIG. **6** is an oblique view of a particular embodiment of a crank axle according to the present invention for use with the crank arm shown in FIG. **1**;

FIG. **7** is a cross sectional view of right and left side crank arms attached to the crank axle shown in FIG. **6**;

FIG. **8** is a cross sectional view illustrating a particular embodiment of a crank arm assembly according to the present invention including a bolt used to fix the crank arms to the crank axle;

FIG. **9** is a partial cross sectional view of alternative embodiment of the bolt shown in FIG. **8**;

FIG. **10** is an oblique view of the bolt shown in FIG. **9**;

FIG. **11** is a partial cross sectional view of a crank axle according to the present invention mounted to a bicycle frame;

FIG. **12** is a cross sectional view illustrating a main tool and an auxiliary tool according to the present invention used to fix chainwheels to the crank arm shown in FIG. **3**;

FIG. **13** is an oblique view of the main tool shown in FIG. **12**;

FIG. **14** is an end view of the tool shown in FIG. **13**; and

FIG. **15** is a partial cross sectional view of the auxiliary tool shown in FIG. **12**.

DETAILED DESCRIPTION OF THE EMBODIMENTS

FIG. **1** is a front view of a particular embodiment of a crank arm **1** according to the present invention. In this

embodiment, the crank arm **1** is fabricated from an aluminum alloy. As shown in FIG. **1**, the crank arm end on the pedal mounting side **4** is narrow, and the crank arm end on the crank axle mounting side **2** is wide. Varying the width of the crank arm **1** depending on the position in this way ensures that the stress bearing on crank arm is essentially constant at any point. A chamfered section **11** is formed at the front sides of the crank arm **1**. The size of the chamfer is greater in proximity to the crank arm end on the crank axle mounting side **2** and becomes continuously smaller towards the crank arm end on the pedal mounting side **4**. The front surface of the crank arm **1** can be inscribed with the manufacturer's logo, a trademark indicating the product name, or the like using laser marking or other means.

A crank axle mounting hole **21** for mounting the crank arm **1** onto the crank axle **5** is formed on the crank axle mounting side **2** of the crank arm **1**. The crank arm **1** is mounted onto the crank axle **5** using this crank axle mounting hole **21** as illustrated in FIG. **6**. A pedal mounting hole **41** is formed at the crank arm end on the pedal mounting side **4** of the crank arm **1**. The pedal (not shown) is mounted in this pedal mounting hole **41**.

FIG. **2** is a side view of the crank arm shown in FIG. **1**, and FIG. **3** is a longitudinal cross sectional view of the crank arm shown in FIG. **1**. As shown in those figures, a groove **31** that extends in the lengthwise direction is formed on the back surface of the central section **3** of the crank arm. The shape of the groove **31** is such that in proximity to the two ends of the groove **31**, the depth of the groove becomes progressively smaller towards each end, with the groove depth reaching a minimum at each end. Thus, the bottom surface of the groove may be termed a "ship hull shape". The bottom surface of the groove **31** in its central section is essentially parallel to the front surface of the central section **3** of the crank arm.

A stepped section **32** is formed at the open side of the groove **31**. A cap member **33** is inserted into this stepped section **32**, and the cap member **33** is affixed at its perimeter to the body of the crank arm **1** by inert gas welding using argon gas. The front surface of the body of the crank arm **1** and the surface of the cap member **33** are flush. The pad produced in welding should be removed by machining or other means in order to make the surface flush.

A crank axle mounting hole **21** is formed on the crank axle mounting side **2**. The inside wall of the crank axle mounting hole **21** has a flange **22** that projects inward, and female splines **23** which are contiguous with the back surface of this flange **22**. The section of the crank axle mounting hole **21** located closer to the back surface than the splines **23** constitutes the centering member **24**. The centering member **24** can be straight, with an inside diameter that does not vary in the axial direction, but more commonly has a tapered shape whose inside diameter flares out towards the back. The taper angle is 2 to 3°. Male splines **25** for locking the chainring **6** in place are formed on the outer periphery of the basal portion of the protruding section located on the back surface of the crank arm end of the crank axle mounting side **2**. A thread **26** for affixing the chainring **6** is formed on the outer periphery of the protruding section on the back surface.

FIG. **4** shows the crank arm **1** viewed from the back. As shown in FIG. **4**, the splines **23** and **25** each comprise eight teeth. Too few teeth results in inadequate linkage strength on the part of the rotary linkage member. Providing too many teeth requires complex machining and entails higher costs, and increases the probability of errors in distribution and positioning in the direction of rotation.

FIGS. **5**A–**5**C are cross sectional views taken along lines **5**A—**5**A, **5**B—**5**B and **5**C—**5**C, respectively, in FIG. **1**. As shown in those figures, the groove **31** constitutes the majority of the cross section interior in the central section **3** of the crank arm in order to decrease the weight.

FIG. **6** shows the exterior of the crank axle **5**. Centering members **52**A,**52**B are formed at each end of the crank axle **5**. The centering members **52**A,**52**B can be straight, with a diameter that does not vary, but they usually have a tapered shape which narrows at the ends. The taper angle is 2 to 3°. Male splines **51**A,**51**B are provided further towards the end from the centering members **52**A,**52**B. The splines **51**A,**51**B have an eight-tooth design. The peripheral surfaces of the splines form continuous unstepped radially outer transition surfaces **555**A and **555**B with the peripheral surfaces of the centering members **52**A,**52**B. The shape of each splines **51**A,**51**B is basically square, or rectangular when viewed perpendicular to the axle axis (X) as shown in FIG. **8**, with the planes of the radially straight sides **51**AX,**51**AY, **51**BX, **51**BY being essentially parallel. The linking force in the direction of rotation is borne by planes which are essentially orthogonal to the direction of force, so chatter is largely eliminated. The innermost ends of splines **51**A, **51**B terminate at rear walls **51**AZ, **51**BZ that are essentially straight radially and essentially perpendicular to axle axis (X). Also, the bottom of splines **51**A, **51**B terminate at bottom floors **51**AW, **51**BW that are essentially straight axially and essentially parallel to axle axis (X) for forming right angle corners **51**AK, **51**BK (FIG. **8**) with rear walls **51**AZ, **51**BZ.

The end faces **49**A,**49**B of the crank axle **5** are provided with internal threads **53** for affixing the crank arms **1**. The crank axle **5** is a hollow pipe whose wall portion **501** is thinner in the central section **502** than wall portions **503**A, **503**B of the centering members **52**A, **52***b*, as shown in FIG. **7**. In this embodiment, an aluminum alloy is used as the material for the crank axle **5**. This, together with the fact that the axle is hollow, contributes to reduced weight.

FIG. **7** depicts the crank axle **5**, the crank arms **1**,**100**, and the chainring **6** in assembled form. The chainring **6** is mounted onto the crank arm **1** on one side, locked in place by the splines **25**, and fixed with a nut **61**. The crank arm **1** to which the chainring **6** has been affixed is mounted onto one end of the crank axle **5** and affixed by a bolt **54**. The crank arm **100** without a chainring attached is affixed to the other end of the crank axle **5**. The centering members **24** of the crank arms **1**,**100** fit tightly with the centering members **52**A,**52**B of the crank axle **5** so that the components are centered with high precision. The female splines **23** of the crank arms **1**,**100** mesh with the male splines **51**A,**51**B of the crank axle **5** to afford a linkage having high strength in the direction of rotation.

The centering members **52**A,**52**B of the aforementioned crank axle **5** and the centering members **24** of the crank arms **1**,**100** have tapered junctions, so the two tapered surfaces fit together tightly. It is therefore necessary to use a removal tool in order to remove the crank arm **1**,**100** from the crank axle **5**. However, the alternative embodiment depicted in FIG. **8** is designed so that a bolt **54** that fastens the crank axle **5** and the crank arm **1** (or **100**) can be used to release the components.

As shown in FIG. **12**, an integrated flange **55** is formed on the head of the bolt **54**. When fastening the crank axle **5** and the crank arm **1** together, a washer **56** is inserted and the bolt **54** is tightened. A stop ring **58** is inserted into and retained by a groove **57** located on the inside surface of the crank axle mounting hole **21**. To remove the crank arm **1** from the crank

axle, a hexagonal Allen key is inserted into the hexagonal hole **59** in the crank arm fixing bolt **54** and turned in the reverse direction. The flange **55** of the bolt **54** then pushes the side surface of the stop ring **58**. The flange **55** thus forces the crank arm **1** in the axial direction, so the tight-fitting tapered junctions of the centering members **52**A,**52**B of the crank axle **5** and the centering members **24** of the crank arms **1** can be easily released. Thus, the need for a special tool such as an extractor is obviated.

FIG. **9** is a partial cross sectional view of alternative embodiment of the bolt shown in FIG. **8**, and FIG. **10** is an oblique view of the bolt shown in FIG. **9**. In the bolt **54** depicted in FIG. **8**, the diameter of the thread section and the diameter of the head are about the same, but in the bolt **54** depicted in FIG. **9** and **10**, the diameter of the thread section **542** is greater than the diameter of the head **541**, and the diameter of the flange **55** is greater than the diameter of the thread section **542**. The provision of a thread section **542** with a large diameter ensures sufficient strength on the part of the thread section even when the component is fabricated from a light alloy such as an aluminum alloy, and affords adequate tightening force on the part of the bolt **54**.

A hexagonal hole **59** formed in the center of the end of the head **541** extends in the direction of the bolt axis. The hexagonal hole **59** extends almost to the distal end of the bolt **54**, such that its bottom surface is located in proximity to the end surface. A longer hexagonal hole **59** provides a greater area of contact between the tightening tool (an Allen key) and the hexagonal hole **59** so that adequate tightening can be achieved even with a light alloy bolt. The length of the hexagonal hole **59** can be chosen in accordance with the tightening force required, but it is necessary for the length to be at least such that the bottom surface of the hexagonal hole **59** extends to the inside surface of the thread section **542**. The diameter of the thread section **542** is rather thick, so the hexagonal hole **59** can extend into its interior; it has adequate strength even when the hexagonal hole **59** is extended into its interior. When fabricated from an aluminum alloy, the bolt **54** has both light weight and adequate strength.

FIG. **11** depicts the crank axle **5** which pertains to the present invention installed in the bicycle frame bottom bracket **10**. The crank axle **5** pertaining to this embodiment is provided with a retainer member **50** which protrudes from the center of its outside surface for retaining the bearings. To install the crank axle **5** in the frame bottom bracket **10**, a left mounting adapter **101** and a right mounting adapter **102** are threaded between the frame bottom bracket **10** and the crank axle **5** so that the bearings are retained by the retainer members **50**. The outsides of the ends of the left mounting adapter **101** and a right mounting adapter **102** are provided with male splines. These male splines mesh with the female splines of the assembly tool **7** so that each adapter can be screwed in.

The design of an assembly tool **7** is shown in FIG. **13**. The end facing the viewer is provided with an essentially regular hexagonal wrench mount member **71**. A wrench or other tool is fitted over the wrench mount member **71**, and the entire assembly tool **7** is rotated around its axis. A middle section **72** is located adjacent to the wrench mount member **71**. The peripheral surface of the middle section **72** is cylindrical, and is cut away at opposing faces to produce flat surfaces. Tools such as wrenches of different sizes can be fitted over the flat sections of the middle section **72**. The other end of the assembly tool **7** has a large-diameter section **73**.

FIG. **14** shows the assembly tool **7** viewed from the large-diameter section **73** side. The inside of the large-diameter section **73** takes the form of an open cavity. As shown in FIG. **14**, female splines **74** are located in the interior. These female splines **74** mesh with the male splines of the left mounting adapter **101** and the right mounting adapter **102**. A through-hole **75** which extends in the axial direction is located in the center of the assembly tool **7**. The diameter of the through-hole **75** is such that the end of the crank axle **5** will pass through it. When the left and right mounting adapters are screwed in, the ends of the crank axle **5** are passed through the through-holes **75** so that the crank axle **5** serves as a guide for rotation of the assembly tool **7**, thus facilitating the assembly operation.

FIG. **12** shows the crank arm **1** with the chainring **6** attached. As illustrated in FIG. **12**, the chainring **6** is mounted onto the crank arm end on the crank axle mounting side **2** of the crank arm **1** and fixed by a nut **61**. The peripheral surface of the nut **61** is provided with male splines having the same pitch as the male splines of the left mounting adapter **101** and the right mounting adapter **102**, as shown in FIG. **11**. Thus, the nut **61** can be tightened using the same assembly tool **7** as that shown in FIG. **11**.

An auxiliary assembly tool **8** is also used in the tightening operation in order to prevent the assembly tool **7** from coming off during tightening. The design of the auxiliary assembly tool **8** is shown in FIG. **15**. One end of the approximately cylindrical auxiliary assembly tool **8** is provided with a grip section **81** whose outside surface has been knurled to prevent slippage. The diameter of the grip section **81** is greater than the diameter of the through-hole **75** of the assembly tool **7**, and it is designed to retained the assembly tool **7**. A inside surface support section **82** is formed next to the grip section **81**. The diameter of the inside surface support section **82** is about the same as the diameter of the end of the crank axle **5**. Thus, the inside surface of the through-hole **75** in the assembly tool **7** can be rotatably supported by the inside surface support section **82**. The other end of the auxiliary assembly tool **8** is provided with a threaded section **83** into which the bolt **54** can be screwed from the end. The length of the auxiliary assembly tool **8** has been designed such that when the auxiliary assembly tool **8** has been fixed to the crank arm **1** by the bolt **54**, there is a slight gap (about 0.5 mm) between the grip section **81** and the assembly tool **7**. Thus, the assembly tool **7** is rotatably supported by the auxiliary assembly tool **8** in such a way that it will not come off from the nut **61**. Thus, a wrench or other tool can be fitted onto the wrench mount member **71** and the nut **61** can be tightened to fix the chainring **6** to the crank arm **1** while the assembly tool **7** is supported by the auxiliary assembly tool **8**. Since the assembly tool **7** is prevented from coming off from the nut **61**, the operation may be conducted easily and efficiently.

While the above is a description of various embodiments of the present invention, further modifications may be employed without departing from the spirit and scope of the present invention. For example, in the embodiment shown in FIG. **8**, a stop ring **58** was provided in crank arm **1**. However, an integrated member which corresponds in function to the stop ring **58** may be formed on the crank arm **1** instead of the stop ring **58**, or some other component may be welded on. Thus, the scope of the invention should not be limited by the specific structures disclosed. Instead, the true scope of the invention should be determined by the following claims. Of course, although labeling symbols are used in the claims in order to facilitate reference to the figures, the present invention is not intended to be limited to the constructions in the appended figures by such labeling.

What is claimed is:

1. A one-piece bicycle crank axle adapted to be rotatably supported within a bottom bracket of a bicycle frame, the axle comprising:

a one-piece axle body having first and second ends defining respective first and second end faces (**49**A, **49**B), wherein the axle body has a hollow central section;

a plurality of first splines (**51**A) disposed at and one-piece with the first end of the axle body;

an unsplined first centering structure (**52**A) disposed at and one-piece with the first end of the axle body in close proximity to the plurality of first splines (**51**A);

wherein the plurality of first splines (**51**A) are dimensioned and positioned to be located externally of the bottom bracket in close proximity to the first end face (**49**A) so as to fit at least partially within a first bicycle crank arm (**100**), and wherein the first centering structure (**52**A) is dimensioned and positioned to be located externally of the bottom bracket in close proximity to the first end face (**49**A) so as to fit at least partially within the first bicycle crank arm (**100**) to center the first bicycle crank arm (**100**) on the axle;

a plurality of second splines (**51**B) disposed at and one-piece with the second end of the axle body;

an unsplined second centering structure (**52**B) disposed at and one-piece with the second end of the axle body in close proximity to the plurality of second splines (**51**B); and

wherein the plurality of second splines (**51**B) are dimensioned and positioned to be located externally of the bottom bracket in close proximity to the second end face (**49**B) so as to fit at least partially within a second bicycle crank arm (**1**), and wherein the second centering structure (**52**B) is dimensioned and positioned to be located externally of the bottom bracket in close proximity to the second end face (**49**B) so as to fit at least partially within the second bicycle crank, arm (**1**) to center the second bicycle crank arm (**1**) on the axle.

2. The crank axle according to claim **1**, wherein the first centering structure (**52**A) is disposed adjacent to the plurality of first splines (**51**A), and wherein the second centering structure (**52**B) is disposed adjacent to the plurality of second splines (**51**B).

3. The crank axle according to claim **2** wherein the plurality of first splines (**51**A) are axially straight and have a diameter that does not vary in an axial direction, and wherein the plurality of second splines (**51**B) are axially straight and have a diameter that does not vary in an axial direction.

4. The crank axle according to claim **1** wherein the plurality of first splines (**51**A) and the first centering structure (**52**A) are tapered to become progressively smaller toward the first end face (**49**A), and wherein the plurality of second splines (**51**B) and the second centering structure (**52**B) are tapered to become progressively smaller toward the second end face (**49**B).

5. The crank axle according to claim **1** wherein the plurality of first splines (**51**A) consists of eight first splines (**51**A), and wherein the plurality of second splines (**51**B) consists of eight second splines (**51**B).

6. The crank axle according to claim **1** wherein the first centering structure (**52**A) is contiguous with the plurality of first splines (**51**A) so that the plurality of first splines (**51**A) are disposed between the first centering structure (**52**A) and the first end face (**49**A), and wherein the second centering structure (**52**B) is contiguous with the plurality of second splines (**51**B) so that the plurality of second splines (**51**B) are disposed between the second centering structure (**52**B) and the second end face (**49**B).

7. The crank axle according to claim **6** wherein an outer peripheral surface of each of the plurality first splines (**51**A) forms a continuous and straight surface with an outer peripheral surface of the first centering structure (**52**A), and wherein an outer peripheral surface of each of the plurality second splines (**51**B) forms a continuous and straight surface with an outer peripheral surface of the second centering structure (**52**B).

8. The crank axle according to claim **7** wherein the first centering structure (**52**A) is unthreaded, and wherein the second centering structure (**52**B) is unthreaded.

9. The crank axle according to claim **1** wherein a wall portion (**501**) of a central section (**502**) of the axle body has a cross sectional thickness less than a wall portion (**503**A) of the first centering structure (**52**A), and wherein the wall portion (**501**) of the central section (**502**) of the axle body has a cross sectional thickness less than a wall portion (**503**B) of the second centering structure (**52**B).

10. The crank axle according to claim **9** wherein the axle body has a constant diameter along its entire length.

11. The crank axle according to claim **1** wherein the plurality of first splines (**51**A) are tapered to become progressively smaller toward the first end face (**49**A), and wherein the plurality of second splines (**51**B) are tapered to become progressively smaller toward the second end face (**49**B).

12. The crank axle according to claim **1** wherein the first centering structure (**52**A) is tapered to become progressively smaller toward the first end face (**49**A), and wherein the second centering structure (**52**B) is tapered to become progressively smaller toward the second end face (**49**B).

13. A one-piece bicycle crank axle adapted to be rotatably supported within a bottom bracket of a bicycle frame, the axle comprising:

a one-piece axle body extending along an axle axis (X) and having first and-second ends defining respective first and second end faces (**49**A,**49**B);

a plurality of first splines (**51**A) disposed at and one-piece with the first end of the axle body, wherein at least one of the plurality of first splines (**51**A) has an essentially square shape when viewed in a direction of the axle axis;

an unsplined first centering structure (**52**A) disposed at and one-piece with the first end of the axle body in close proximity to the plurality of first splines (**51**A), wherein a transition surface (**555**A) between the plurality of first splines (**51**A) and the first centering structure (**52**A) is an unstepped radially outer surface;

wherein the plurality of first splines (**51**A) are dimensioned and positioned to be located externally of the bottom bracket in close proximity to the first end face (**49**A) so as to fit at least partially within a first bicycle crank arm (**100**), and wherein the first centering structure (**52**A) is dimensioned and positioned to be located externally of the bottom bracket in close proximity to the first end face (**49**A) so as to fit at least partially within the first bicycle crank arm (**100**) to center the first bicycle crank arm (**100**) on the axle;

a plurality of second splines (**51**B) disposed at and one-piece with the second end of the axle body;

an unsplined second centering structure (**52**B) disposed at and one-piece with the second end of the axle body in

close proximity to the plurality of second splines (**51**B), wherein a transition surface (**555**B) between the plurality of second splines (**51**B) and the second centering structure (**52**B) is an unstepped radially outer surface; and

wherein the plurality of second splines (**51**B) are dimensioned and positioned to be located externally of the bottom bracket in close proximity to the second end face (**49**B) so as to fit at least partially within a second bicycle crank arm (**1**), and wherein the second centering structure (**52**B) is dimensioned and positioned to be located externally of the bottom bracket in close proximity to the second end face (**49**B) so as to fit at least partially within the second bicycle crank arm (**1**) to center the second bicycle crank arm (**1**) on the axle.

14. The crank axle according to claim **13** wherein each of the plurality of first splines (**51**A) has an essentially square shape.

15. The crank axle according to claim **14** wherein each of the plurality of second splines (**51**B) has an essentially square shape.

16. A one-piece bicycle crank axle adapted to be rotatably supported within a bottom bracket of a bicycle frame, the axle comprising:

a one-piece axle body extending along an axle axis (X) and having first and second ends defining respective first and second end faces (**49**A, **49**B);

a plurality of first splines (**51**A) disposed at and one-piece with the first end of the axle body, wherein at least one of the plurality of first splines (**51**A) has an essentially rectangular shape when viewed perpendicular to the axle axis (X);

an unsplined first centering structure (**52**A) disposed at and one-piece with the first end of the axle body in close proximity to the plurality of first splines (**51**A), wherein a transition surface (**555**A) between the plurality of first splines (**51**A) and the first centering structure (**52**A) is an unstepped radially outer surface;

wherein the plurality of first splines (**51**A) are dimensioned and positioned to be located externally of the bottom bracket in close proximity to the first end face (**49**A) so as to fit at least partially within a first bicycle crank arm (**100**), and wherein the first centering structure (**52**A) is dimensioned and positioned to be located externally of the bottom bracket in close proximity to the first end face (**49**A) so as to fit at least partially within the first bicycle crank arm (**100**) to center the first bicycle crank arm (**100**) on the axle;

a plurality of second splines (**51**B) disposed at and one-piece with the second end of the axle body;

an unsplined second centering structure (**52**B) disposed at and one-piece with the second end of the axle body in close proximity to the plurality of second splines (**51**B), wherein a transition surface (**555**B) between the plurality of second splines (**51**B) and the second centering structure (**52**B) is an unstepped radially outer surface; and

wherein the plurality of second splines (**51**B) are dimensioned and positioned to be located externally of the bottom bracket in close proximity to the second end face (**49**B) so as to fit at least partially within a second bicycle crank arm (**1**), and wherein the second centering structure (**52**B) is dimensioned and positioned to be located externally of the bottom bracket in close proximity to the second end face (**49**B) so as to fit at least partially within the second bicycle crank arm (**1**), to center the second bicycle crank arm (**1**) on the axle.

17. The crank axle according to claim **16** wherein each of the plurality of first splines (**51**A) has an essentially rectangular shape when viewed perpendicular to the axle axis (X).

18. The crank axle according to claim **17** wherein each of the plurality of second splines (**51**B) has an essentially rectangular shape when viewed perpendicular to the axle axis (X).

19. A one-piece bicycle crank axle adapted to be rotatably supported within a bottom bracket of a bicycle frame, the axle comprising:

a one-piece axle body extending along an axle axis (X) and having first and second ends defining respective first and second end faces (**49**A, **49**B);

a plurality of first splines (**51**A) disposed at and one-piece with the first end of the axle body, wherein an inner end of at least one of the plurality of first splines (**51**A) terminates at a first spline rear wall (**51**AZ) that has an essentially straight portion in the radial direction;

an unsplined first centering structure (**52**A) disposed at and one-piece with the first end of the axle body in close proximity to the plurality of first splines (**51**A), wherein a transition surface (**555**A) between the plurality of first splines (**51**A) and the first centering structure (**52**A) is an unstepped radially outer surface;

wherein the plurality of first splines (**51**A) are dimensioned and positioned to be located externally of the bottom bracket in close proximity to the first end face (**49**A) so as to fit at least partially within a first bicycle crank arm (**100**), and wherein the first centering structure (**52**A) is dimensioned and positioned to be located externally of the bottom bracket in close proximity to the first end face (**49**A) so as to fit at least partially within the first bicycle crank arm (**100**) to center the first bicycle crank arm (**100**) on the axle;

a plurality of second splines (**51**B) disposed at and one-piece with the second end of the axle body;

an unsplined second centering structure (**52**B) disposed at and one-piece with the second end of the axle body in close proximity to the plurality of second splines (**51**B), wherein a transition surface (**555**B) between the plurality of second splines (**51**B) and the second centering structure (**52**B) is an unstepped radially outer surface; and

wherein the plurality of second splines (**51**B) are dimensioned and positioned to be located externally of the bottom bracket in close proximity to the second end face (**49**B) so as to fit at least partially within a second bicycle crank arm (**1**), and wherein the second centering structure (**52**B) is dimensioned and positioned to be located externally of the bottom bracket in close proximity to the second end face (**49**B) so as to fit at least partially within the second bicycle crank arm (**1**) to center the second bicycle crank arm (**1**) on the axle.

20. The crank axle according to claim **19** wherein the first spline rear wall (**51**AZ) is essentially perpendicular to the axle axis (X).

21. The crank axle according to claim **19** wherein a bottom of the at least one of the plurality of first splines (**51**A) terminates at a first spline bottom floor (**51**AW) that has an essentially straight portion in the direction of the axis (X).

22. The crank axle according to claim **21** wherein the first spline bottom floor (**51**AW) is essentially parallel to axle axis (X).

23. The crank axle according to claim **22** wherein the first spline rear wall (**51**AZ) is essentially perpendicular to the axle axis (X).

24. The crank axle according to claim **23** wherein the first spline bottom floor forms a first spline right angle corner (**51**AK) with the first spline rear wall (**51**AZ).

25. The crank axle according to claim **19** wherein an inner end of each of the plurality of first splines (**51**A) terminates at a first spline rear wall (**51**AZ) that has an essentially straight portion in the radial direction.

26. The crank axle according to claim **25** wherein each first spline rear wall (**51**AZ) is essentially perpendicular to the axle axis (X).

27. The crank axle according to claim **25** wherein a bottom of each of the plurality of first splines (**51**A) terminates at a first spline bottom floor (**51**AW) that has an essentially straight portion in the direction of the axis (X).

28. The crank axle according to claim **27** wherein each first spline bottom floor (**51**AW) is essentially parallel to axle axis (X).

29. The crank axle according to claim **22** wherein each first spline rear wall (**51**AZ) is essentially perpendicular to the axle axis (X).

30. The crank axle according to claim **29** wherein each first spline bottom floor forms a first spline right angle corner (**51**AK) with its corresponding first spline rear wall (**51**AZ).

31. The crank axle according to claim **25**, wherein an inner end of each of the plurality of second splines (**51**B) terminates at a second spline rear wall (**51**BZ) that has an essentially straight portion in the radial direction.

32. The crank axle according to claim **31** wherein each first spline rear wall (**51**AZ) is essentially perpendicular to the axle axis (X), and wherein each second spline rear wall (**51**BZ) is essentially perpendicular to the axle axis (X).

33. The crank axle according to claim **31** wherein a bottom of each of the plurality of first splines (**51**A) terminates at a first spline bottom floor (**51**AW) that has an essentially straight portion in the direction of the axis (X), and wherein a bottom of each of the plurality of second splines (**51**B) terminates at a second spline bottom floor (**51**BW) that has an essentially straight portion in the direction of the axis (X).

34. The crank axle according to claim **33** wherein each first spline bottom floor (**51**AW) is essentially parallel to axle axis (X), and wherein each second spline bottom floor (**51**BW) is essentially parallel to axle axis (X).

35. The crank axle according to claim **34** wherein each first spline rear wall (**51**AZ) is essentially perpendicular to the axle axis (X), and wherein each second spline rear wall (**51**BZ) is essentially perpendicular to the axle axis (X).

36. The crank axle according to claim **35** wherein each first spline bottom floor (**51**AW) forms a first spline right angle corner (**51**AK) with its corresponding first spline rear wall (**51**AZ), and wherein each second spline bottom floor (**51**BW) forms a second spline right angle corner (**51**BK) with its corresponding second spline rear wall (**51**BZ).

37. The crank axle according to claim **36** wherein the plurality of first splines (**51**A) are axially straight and have a diameter that does not vary in an axial direction, and wherein the plurality of second splines (**51**B) are axially straight and have a diameter that does not vary in an axial direction.

38. A one-piece bicycle crank axle adapted to be rotatably supported within a bottom bracket of a bicycle frame, the axle comprising:

a one-piece axle body extending along an axle axis (X) and having first and second ends defining respective first and second end faces (**49**A, **49**B);

a plurality of first splines (**51**A) disposed at and one-piece with the first end of the axle body, wherein at least one of the plurality of first splines includes a first spline side wall (**51**AX) with a radially straight portion, and wherein an inner end of the at least one of the plurality of first splines (**51**A) terminates at a first spline rear wall (**51**AZ);

an unsplined first centering structure (**52**A) disposed at and one-piece with the first end of the axle body in close proximity to the plurality of first splines (**51**A), wherein a transition surface (**555**A) between the plurality of first splines (**51**A) and the first centering structure (**52**A) is an unstepped radially outer surface;

wherein the plurality of first splines (**51**A) are dimensioned and positioned to be located externally of the bottom bracket in close proximity to the first end face (**49**A) so as to fit at least partially within a first bicycle crank arm (**100**), and wherein the first centering structure (**52**A) is dimensioned and positioned to be located externally of the bottom bracket in close proximity to the first end face (**49**A) so as to fit at least partially within the first bicycle crank arm (**100**) to center the first bicycle crank arm (**100**) on the axle;

a plurality of second splines (**51**B) disposed at and one-piece with the second end of the axle body;

an unsplined second centering structure (**52**B) disposed at and one-piece with the second end of the axle body in close proximity to the plurality of second splines (**51**B), wherein a transition surface (**555**A) between the plurality of second splines (**51**B) and the second centering structure (**52**B) is an unstepped radially outer surface; and

wherein the plurality of second splines (**51**B) are dimensioned and positioned to be located externally of the bottom bracket in close proximity to the second end face (**49**B) so as to fit at least partially within a second bicycle crank arm (**1**), and wherein the second centering structure (**52**B) is dimensioned and positioned to be located externally of the bottom bracket in close proximity to the second end face (**49**B) so as to fit at least partially within the second bicycle crank arm (**100**) to center the second bicycle crank arm (**1**) on the axle.

39. The crank axle according to claim **38** wherein a bottom of the at least one of the plurality of first splines (**51**A) terminates at a first spline bottom floor (**51**AW) that has an essentially straight portion in the direction of the axis (X).

40. The crank axle according to claim **39** wherein the first spline bottom floor (**51**AW) is essentially parallel to axle axis (X).

41. The crank axle according to claim **40** wherein the first spline rear wall (**51**AZ) has a portion that is essentially straight and perpendicular to the axle axis (X).

42. The crank axle according to claim **41** wherein the first spline bottom floor forms a first spline right angle corner (**51**AK) with the first spline rear wall (**51**AZ).

43. The crank axle according to claim **38** wherein each of the plurality of first splines (**51**A) includes a side wall (**51**AX) with a radially straight portion, and wherein an inner end of each of the plurality of first splines (**51**A) terminates at a first spline rear wall (**51**AZ).

44. The crank axle according to claim **43** wherein each of the plurality of second splines (**51**B) includes a side wall (**51**BX) with a radially straight portion, and wherein an inner end of each of the plurality of second splines (**51**B) terminates at a second spline rear wall (**51**BZ).

45. The crank axle according to claim **44** wherein a bottom of each of the plurality of first splines (**51**A) termi-

nates at a first spline bottom floor (**51**AW) that has an essentially straight portion in the direction of the axis (X), and wherein a bottom of each of the plurality of second splines (**51**B) terminates at a second spline bottom floor (**51**BW) that has an essentially straight portion in the direction of the axis (X).

46. The crank axle according to claim **45** wherein each first spline bottom floor (**51**AW) is essentially parallel to axle axis (X), and wherein each second spline bottom floor (**51**BW) is essentially parallel to axle axis (X).

47. The crank axle according to claim **46** wherein each first spline rear wall (**51**AZ) has a portion that is essentially straight and perpendicular to the axle axis (X), and wherein each second spline rear wall (**51**BZ) has a portion that is essentially straight and perpendicular to the axle axis (X).

48. The crank axle according to claim **47** wherein each first spline bottom floor (**51**AW) forms a first spline right angle corner (**51**AK) with its corresponding first spline rear wall (**51**AZ), and wherein each second spline bottom floor (**51**BW) forms a second spline right angle corner (**51**BK) with its corresponding second spline rear wall (**51**BZ).

49. The crank axle according to claim **48** wherein the plurality of first splines (**51**A) are axially straight and have a diameter that does not vary in an axial direction, and wherein the plurality of second splines (**51**B) are axially straight and have a diameter that does not vary in an axial direction.

50. A one-piece bicycle crank axle adapted to be rotatably supported within a bottom bracket of a bicycle frame, the axle comprising:

a one-piece axle body having first and second ends defining respective first and second end faces (**49**A, **49**B), wherein the axle body has an unthreaded hollow section;

a plurality of first splines (**51**A) disposed at and one-piece with the first end of the axle body;

an unsplined first centering structure (**52**A) disposed at and one-piece with the first end of the axle body in close proximity to the plurality of first splines (**51**A);

wherein the plurality of first splines (**51**A) are dimensioned and positioned to be located externally of the bottom bracket in close proximity to the first end face (**49**A) so as to fit at least partially within a first bicycle crank arm (**100**), and wherein the first centering structure (**52**A) is dimensioned and positioned to be located externally of the bottom bracket in close proximity to the first end face (**49**A) so as to fit at least partially within the first bicycle crank arm (**100**) to center the first bicycle crank arm (**100**) on the axle;

a plurality of second splines (**51**B) disposed at and one-piece with the second end of the axle body;

an unsplined second centering structure (**52**B) disposed at and one-piece with the second end of the axle body in close proximity to the plurality of second splines (**51**B); and

wherein the plurality of second splines (**51**B) are dimensioned and positioned to be located externally of the bottom bracket in close proximity to the second end face (**49**B) so as to fit at least partially within a second bicycle crank arm (**1**), and wherein the second centering structure (**52**B) is dimensioned and positioned to be located externally of the bottom bracket in close proximity to the second end face (**49**B) so as to fit at least partially within the second bicycle crank arm (**1**) to center the second bicycle crank arm (**1**) on the axle.

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